Coupling TURBOdesign1 with Automatic Optimisation as Ebm-Papst to Design Efficient and Low Cost Centrifugal Fans.

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Introduction

Ebm-papst Mulfingen was founded in 1963 by Gerhard Sturm, still actively heading the company, and Heinz Ziehl. Everything started with the external-rotor motor which was rediscovered then as an ideal drive for small fans. As the pillar and basic principle of our innovative and wide product range, the external-rotor motor made Ebm the world market leader. In the 1970s, both Ebm and Papst were innovators in the field of brushless EC drives. This guaranteed them an important edge in terms of know-how that they have been able to maintain right up to the present day. In 1992, Ebm took over PAPST Motoren GmbH & Co. KG, following this up in 1997 by acquiring MVL Motoren Ventilatoren Landshut GmbH. The Ebm, Papast and MVL companies took the joint brand name Ebm-papst in 2003.

Today, with approximately 10,000 people in 57 subsidiaries and 17 production facilities worldwide, Ebm-papst produces high quality fans and motors for many markets such as heating and air-conditioning, ventilation, refrigeration, automotive, IT/telecom and drive technology. The turnover of the whole group was 1,076 million in the fiscal year 07/08. The Ebm-papst product portfolio comprises about 14500 different items and the global production in 2007/08 was 55.6 million fans and motors.

Motivation

At Ebm-papst, we have been using TURBOdesign1 for fan blade design for a number of years now. Our experience shows that TURBOdesign1 can reduce development / design time, improve efficiency and reduce noise of fan blades. However, using an inverse design tool like TURBOdesign1 to design a fan blade for a radial impeller, the resulting blade is a full three dimensional one, that means it is curved arbitrarily in radial and axial directions. In order to reduce manufacturing costs, it is important in some cases to produce the fans with 2D blades that are curved only in the radial direction. However, 2D blades often result in an efficiency loss. In order to obtain the best compromise between efficiency and reduced manufacturing costs TURBOdesign1 was coupled with an automatic optimisation method.
Automatic optimization process
TURBOdesign1 has a script version that can be easily coupled with any automatic optimiser. The most important design parameters such as blade loading can be controlled by simple text files such as .pcf file. In addition, TURBOdesign1 output files can be used to evaluate both aerodynamic and geometrical parameters directly by the optimiser. The design process with TURBOdesign1 being very fast, thousands of designs can be carried out overnight, allowing even optimisations with more than 20 input variables. The optimisation target is to minimise the deviation of the mid surface from the desired 2D blade subject to constraints on the diffusion ratios below a critical value to avoid flow separation. The main design parameters are the blade loading distribution in stream wise direction on different span-wise positions. However, the meridional channel, the thickness distribution and the main specifications such as impeller speed, blade number and volume flow rate remained fixed during the optimisation. The original design was a 3D blade designed with TURBOdesign1 (Fig. 1), which already showed very good performance and had excellent efficiency, but was difficult and expensive to manufacture. The geometrically optimised blade (Fig. 2) has almost the same aerodynamic values as the original 3D blade (Fig. 3) and can be manufactured cost-effectively.

Conclusion
The resulting optimised 2D blade addresses very well the manufacturing constraints and shows the same excellent values for performance and efficiency as the original 3D blade. Manufacturing constraints are only one of numerous possible design targets that can be accomplished by coupling TURBOdesign1 with an automatic optimiser, since this method can be used almost universally.

“The ability of TURBOdesign1 to optimize the fan performance at a specific duty point was decisive. Optimising the fan impeller design reduced the noise generation by 5 to 6dB. The new generation of IG Fan has been very well received by our customers.”

Image 3. CFD results of TURBOdesign1 designs for 3D and 2D blade
Image 4. Distribution of static pressure on blade surface for optimised 2D blade